Carnegie Mellon's Software Engineering Institute Focuses Expertise on the Transformation of Army Acquisition

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I n 1999, the U.S. Army embarked on one of its most ambitious missions to date: completely reinventing itself. In his 1999 statement to the House Armed Services Committee, then Army Chief of Staff Eric Shinseki called it "transforming the most respected Army in the world" into one that is "dominant at every point on the spectrum of operations." Much of the focus since then has been on revolutionary weapons concepts such as the Future Combat Systems and Future Warrior. The now famous "pitchfork" diagram (Figure 1), which symbolized the fusion of legacy and interim forces with science and technology to produce the Objective Force, became the ubiquitous symbol of transformation and a de rigueur element of every industry briefing aimed at winning Army business.

Media interest is inevitably concentrated on remarkable new technologies (see sidebar "Technology: The Public Face of Army Transformation"); however, the real substance of Army transformation lies in changing the fundamental way the service operates at all levels and adapting everything it does to meet the challenges of the new millennium. As General Kevin Byrnes, commander of the Army's Training and Doctrine Command, noted in his February 2003 article in *Army*, change is required in "our organizations, our methods, our materiel, our structure and our institutions." One of the key elements of transformation is to improve the way that software

Force XXI Battle Command Battalion/Brigade and Below (FBCB2) System
Photo courtesy Northrup Grumman

intensive systems (SIS) are procured for our warfighters. This is especially important as software becomes the pervasive element in everything from aircraft to bullets. The Bob Stump National Defense Authorization Act for fiscal year 2003 underscores the importance of improving acquisitions involving software: Section 804 requires the military to establish process improvement programs specifically targeted at software acquisition for systems with a significant software component.

In 2002, the Software Engineering Institute (SEI[SM]) at Carnegie Mellon University established the Acquisition Support Program (ASP) as a means of helping all the military services manage the acquisition of SIS effectively.

The goal of the ASP is to apply good practices from all sources in order to ameliorate the acquisition challenges of increasingly complex systems and ensure that the U.S. military has agile and robust procurement processes to meet the needs of 21st century warfighters. "By taking advantage of the science and technology investment in the SEI over the past 17 years, we are able to apply new and improved software engineering and acquisition practices to provide direct assistance to challenging DoD acquisition programs like FCS, Joint Strike Fighter, DD(X), and a whole host of others," says Brian Gallagher, director of ASP. (DD(X) is the new multi-mission surface combatant ship currently under development for the Navy.)

Blanchette is senior member of the technical staff at the Software Engineering Institute in Pittsburgh, where he specializes in acquisition improvement initiatives for the U.S. Army. He is a graduate of Embry-Riddle Aeronautical University and has over 16 years of experience working in software development and management for Army systems.

Army Strategic Software Improvement Program

Even before Congress wrote the Section 804 language, Claude Bolton, assistant secretary of the Army for Acquisition, Logistics, and Technology (ASA(ALT)) and the Army's acquisition executive, recognized the challenges facing Army acquisition and proactively entered into a partnership with the SEI to create the Army Strategic Software Improvement Program (ASSIP). The ASSIP is a long-

RAH–66 Comanche
Photo courtesy Sikorsky

term, broad-reaching program designed to improve the quality of software developed for Army SIS. With its focus on programs, people, production, and continuous improvement, ASSIP will create a predictable, quantitative, experience-based, and repeatable process that enables successful SIS acquisition.

Bolton tasked the SEI to be "on point"—in other words, to play a key role in defining the infrastructure needed to support the ASSIP—as well as to take the lead in developing the Strategic Software Improvement Master Plan (SSIMP). The SSIMP is a fundamental element of the ASSIP, identifying the improvement initiatives to be undertaken in each fiscal year and thereby providing the roadmap for program execution.

The SEI is working closely with representatives of the Army's program executive officers (PEOs) to develop and im-

plement the SSIMP. Organized as the ASSIP Action Group (AAG) and actively engaged in making the ASSIP a success are the SEI, the PEO representatives, the Army Materiel Command's software engineering directorates and centers, and other organizations closely tied to Army acquisition. A senior steering group, consisting of the PEOs and chaired by the military deputy to the ASA(ALT), will review and approve yearly updates of the SSIMP and fund its ongoing initiatives.

The SEI acts as a catalyst to identify potential initiatives and bring them before the AAG for discussion. Initiatives may take the form of pilot programs to validate promising ideas in an actual acquisition context or implementation of mature, proven techniques on a broader scale. Government, the SEI, industry, and academia are all potential sources of initiatives.

A Key ASSIP Initiative: Baselining Army SIS Acquisition

As one of the key initiatives of ASSIP, the SEI is actively cultivating an understanding of Army acquisition practices in order to develop a baseline state of Army SIS acquisition. This baseline will, in turn, be used to determine where and how to focus other improvement efforts across Army acquisition. Techniques used in the baselining process include direct engagements with programs and surveys of key Army acquisition pro-

fessionals. All acquisition category (ACAT) I and II programs will eventually participate in the benchmarking process. The goal is to help individual programs now, while simultaneously identifying improvement opportunities

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(called benchmarks) for the broader Army acquisition enterprise.

Armed with an understanding of the baseline state, the SEI will research the most promising technologies available industry-wide to foster improvements to the Army acquisition system. The programs participating in direct engagements receive a triple benefit: first, immediate feedback about their current practices; second, early adoption of improvement strategies; and third, the opportunity to critique to higher levels the policies that affect how they accomplish their missions. Through an ongoing relationship with the SEI, the programs also benefit from continued expert con-
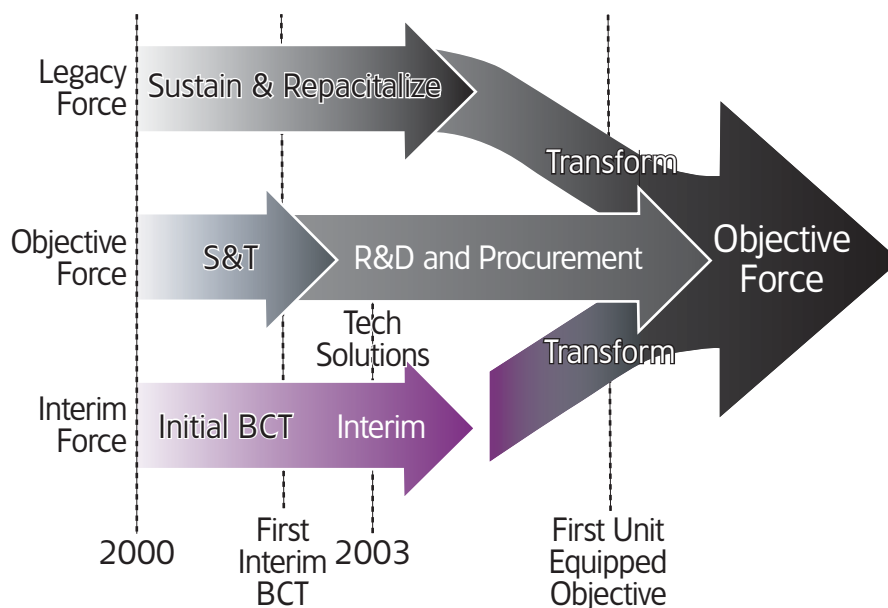
FIGURE. 1. **Army Transformation into the Objective Force**

sultation to monitor the successes and shortcomings of improvement strategies. In addition, the SEI will assist all ACAT I and II programs in setting up their own acquisition process improvement plans.

ASSIP represents the Army's comprehensive and far-reaching response to Section 804. It also provides an umbrella under which other equally important work is carried out. The SEI has several direct engagements that are ongoing to help individual programs in the near term.

Future Combat Systems

From a warfighting perspective, the Future Combat Systems (FCS) will be the centerpiece of tomorrow's battlefield. The FCS vision is not just a single vehicle or even a family of vehicles, but a network-centric force composed of platforms of many types able to fight in a unified and coordinated manner. The program—a collaborative effort between the Army, the Defense Advanced Research Projects Agency (DARPA), and industry—seeks to acquire a "system of systems" in which software will play a significant and vital role. An industry-based lead system integrator (LSI) team will handle many tasks traditionally performed by a government program office. Managing the technology alone

would be difficult enough, but the scope and complexity of this bold program introduce acquisition challenges many times greater than those experienced in previous Army programs.

The Army asked the SEI to take a hands-on role in a number of areas. The SEI participates in the FCS Software Steering Committee, collaborating with the LSI team, the government, and other organizations to identify and resolve program issues that impact on, or may be impacted by, software. As part of the steering committee, the SEI also provides consultation on FCS software risks and risk management and supports the LSI's efforts to develop a variety of documents, including the software development plan. Although it does not participate as a voting member in source selection activities, the SEI does provide expert review of requests for proposal prior to their release. In addition, the SEI assists both the LSI and the Army's FCS program office in establishing and improving software acquisition management processes for the program. One notable example is the Software Acquisition Capability Maturity Model® (SA-CMM®) training provided to program participants in June 2003.

During the concept and technology development (CTD) phase of the program,

the SEI supported the LSI in evaluating and applying a number of SEI-developed technologies, including product line approaches for FCS software development, strategies for including commercial off-the-shelf (COTS) products in the designs, and architecture evaluation using the Architecture Tradeoff Analysis Method[SM] (ATAM[SM]). One of the direct benefits of this work has been the inclusion of an 18-month architecture development effort during the recently authorized system development and demonstration (SDD) phase of the program. An integral part of the program's plan for SDD, periodic ATAM evaluations ensure that the FCS architecture will meet its quality attribute goals in addition to its technical requirements. The SEI also plays a continuing role on the program's Software Architecture Working Group.

Since the program intends to maximize software reuse to help meet its demanding schedule, the SEI conducted a pilot program to investigate the feasibility of software reuse on FCS. The SEI's Options Analysis for Reengineering[SM] (OAR[SM]) method seeks to evaluate the risks, costs, and benefits of reusing software for large, complex systems. For FCS, this method was adapted to allow the LSI to make decisions across the supplier base about abilities to contribute reusable assets to the program effectively. Employing the modified OAR process allows the LSI to obtain more realistic estimates for the amount of reusable software available, which in turn builds confidence in overall software size and effort estimations for the program.

Objective Force Leader: Comanche Helicopter Program

The Comanche helicopter is the lead system in the Army's transformation to the Objective Force. Designed to be the Army's next generation scout/reconnaissance and attack platform, Comanche will bring revolutionary capability to the warfighter through a suite of sophisticated integrated sensors that will facilitate enemy engagements in day, night, and adverse weather conditions. Its low-observable features will allow Comanche to operate with a level of

stealth not previously possible for a helicopter.

The Comanche program manager (PM) engaged the SEI to work directly with the staff of the program management office (PMO) to improve its acquisition processes and capabilities. The goal of this work is to develop improved practices for systems acquisition and life cycle systems engineering as well as to expand workforce competencies in systems acquisition. To that end, the SEI is evaluating the applicability to Comanche's needs of certain elements of its Capability Maturity Model® (CMM®) frameworks for software acquisition and systems engineering and its CMM Integration® (CMMI®) framework (see sidebar "Process Models: One Size Does Not Fit All"). The SEI is also participating in the formation of the PMO's acquisition improvement group (AIG) and is providing coaching to its members. Together, the PMO AIG and the SEI have developed a plan for the process improvement effort and are putting that plan into action. As the effort continues, the SEI will provide training in several key areas, including managing technological change, planning for strategic improvement, metrics and measurement, and elements of maturity models appropriate to integrated product teams. The PMO's goal, beyond formal assessment at Level 3 of the CMM for software acquisition, is to demonstrate improved acquisition capability while delivering one of the cornerstone systems of the Objective Force.

The Digital Battlefield: Force XXI Battle Command, Brigade and Below
The Force XXI Battle Command Battalion/Brigade and Below (FBCB2) program is the backbone of the Army's digital battlefield for brigade and lower-level echelons. Providing command and control and situational awareness, FBCB2 gives the advantage to U.S. commanders, enabling decisive action through superior battlefield information as the fight develops. The system also gives commanders an enhanced ability to tell friend from foe in the fog of war—an ability so crucial that even before undergoing operational testing, FBCB2 software was deployed to support Operation Iraqi Freedom.

To help ensure that FBCB2 will meet the force's needs into the future, the Army called upon the SEI to evaluate the system's software architecture and make recommendations. Working with the FBCB2 program office and its prime contractor, the SEI assisted with near-term architectural improvements to enhance the flexibility of the FBCB2 product to meet new short-term requirements that have evolved from its tremendous success to date. The SEI is also participating in the definition of an objective architecture that, once implemented, will allow FBCB2 to grow and adapt to meet expanding Army needs, both foreseen and unforeseen.

Technology Transition
In September 2002, the SEI opened an on-site impact center in Huntsville, Ala. The center is co-located with the Software Engineering Directorate (SED) of the U.S. Army Aviation and Missile Command (AMCOM) Research Development and Engineering Center. SED is a software powerhouse in its own right: it is one of the few government agencies to have achieved Level 4 of the Software Capability Maturity Model® (SW-CMM®) framework. As such, the partnership between the SEI and AMCOM is ideally suited to forward the missions of both organizations.

The goal of SEI's Huntsville center—consistent with the missions of both SEI and SED—is technology transition. The Huntsville area provides fertile ground for the success of the partnership. In addition to AMCOM, Huntsville is home to the Army's Space and Missile Defense Command; the PEOs for aviation, tactical missiles, and air, space, and missile defense; NASA's Marshall Space Flight Center; and an ever-expanding group of aerospace/defense contractors and high-tech companies. Together with SED, the SEI will deliver mature software development technologies to the local community as well as to the Army Materiel Command and the overall Army acquisition community. The expected

outcome is the establishment of organizations that are better able to adapt as development and acquisition technologies change and evolve.

Other SEI Endeavors
In another effort underway for Bolton, the SEI is developing acquisition planning guidelines for programs with sig-

nificant software content. The aim of this endeavor is to distill a set of guidelines that can form a basis for planning future acquisition efforts by monitoring contracting processes on representative programs and then combining the knowledge gained with the breadth of the SEI's acquisition experience. Once the guidelines have been developed, they will be piloted on another program to prove-out the concepts and ensure the effects are beneficial. The SEI also will use the pilot results to refine the guidelines before finalizing them. The Army plans to use the finished product to help PMs develop effective plans for addressing the challenges posed by software in their system acquisitions.

A further avenue of endeavor that the SEI is undertaking in support of Army acquisition is the development of a "software survival" course. Originally requested by Army Maj. Gen. Joseph Yakovac, PEO for Ground Combat Systems, the course covers a wide range of software-related issues that directly or indirectly influence the planning and management of acquisition programs. PEOs and PMs make up the target audience for the course, and the intent is to provide them with the knowledge they need to make informed decisions about the software aspects of the programs they control. The curriculum addresses topics that span the system life cycle, beginning with pre-award activities. Included are resources and references that acquisition managers can bring to bear on problems, as well as a discussion of problems that frequently plague the acquisition process.

Tying It All Together: Army Strategic Impact Program

The Army Strategic Impact Program (SIP) is the overarching strategy that binds all these efforts together in a coherent manner. Fully embraced by the Army, the program is overseen by an SEI sector manager and a chief engineer, who are dedicated full time to the Army customer. The SIP provides a three-pronged approach toward improving Army acquisition. First, by working with strategic acquisition partners, the SEI strives to build lasting relationships and

develop long-term answers to Army-wide acquisition challenges (as exemplified by the ASSIP and Acquisition Guidelines efforts). Second, the SEI employs strategic transition partners, such as AMCOM SED, to broaden the reach of relevant technologies to the widest possible audience. Third, the SEI exploits current techniques to achieve near-term gains for its individual tactical transition customers like PM Comanche. The Army chief engineer ensures delivery of consistent and harmonized solutions, governs all technical activities, and works closely with the SEI's chief engineers for the other services to maximize the cross-pollination of ideas.

Beyond Army Acquisition

The work described in this article represents only a fraction of the acquisition activities that the SEI conducts on behalf of the U.S. Government. The SEI supports all branches of the service in their quest to transform in order to meet the combat needs of the future. The SEI is also developing strategic impact programs, similar to those already in place

for the Army, for each of the other military services. In addition, the SEI is actively engaged with non-defense agencies, including the Coast Guard, the National Reconnaissance Office, the Internal Revenue Service, U.S. Customs, the National Security Agency, and the National Imagery and Mapping Agency, to help them improve their SIS acquisition efforts. Through hands-on participation, application of good practices, piloting of new approaches, collaboration, and training, the SEI is ensuring the U.S. military can acquire high-quality, software-intensive systems rapidly and efficiently to support the warfighter.

Process Models: One Size Does Not Fit All

SW–CMM®	SA–CMM®	CMMI®
Focused on software development	Focused on software acquisition	Focused on product development
Considers process areas from a software development perspective	Considers process areas from a software acquisition or program office perspective	Considers process areas from a cross–functional perspective (specifically, software development, systems engineering, and product development disciplines)
Practices are those that tend to increase the likelihood of a successful *development* effort	Practices are those that tend to increase the likelihood of a successful *acquisition* effort	Practices are those that tend to increase the likelihood of a successful *development* effort

Years of experience working with acquisition organizations show that many project offices have significant technical responsibilities (e.g., systems engineering) in addition to acquisition management tasks. Since none of the above models accurately reflects such a mode of business operation, the Comanche program and the Air Force's Space and Missile Systems Center are exploring hybrid CMMI/SA–CMM frameworks as part of their process improvement efforts.

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